DOCUMENT RESUME

ED 193 327 TM 800 645

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TITLE Reconstructive Memory: A Non-Traditional Approach to Assessing Young Children's Intelligence.
PUB DATE Apr 80
NOTE 23p.; Paper presented at the American Educational Research Association (64th, Boston, MA, April 7-11, 1980).

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Cognitive Measurement; Concept Formation; *Developmental Stages; Intelligence; *Intelligence Tests; Kinesthetic Perception; Learning Theories; *Memory; Pattern Recognition; *Preschool Children; Preschool Education; Test Construction
IDENTIFIERS *Piagetian Tasks; Piagetian Theory; *Reconstructive Memory

ABSTRACT

Implications are discussed for new instrument development by way of a methodological study which used a task allowing one to focus upon: (1) a non-verbal approach; (2) memory functions; (3) a variety of mnemonics that children use in information retrieval; and (4) a non-traditional procedure supported by psychological and developmental research. A Piagetian memory task (Static Imagery) was adapted to study the respective roles of color, form, and spatial cues in preschoolers' memory. A seven-element array of variously colored geometric forms was shown to each of 59 four- and five-year olds for 30 seconds, after which an experimenter destroyed the arrangement, mixed the forms, and asked the child to rebuild the pattern. The task allowed for an analysis of the child's (1) search and selection strategies; (2) approach to pattern reconstruction; (3) correctness of patterns, with the possibility for partial correctness; (4) classification skills based on the error pattern analysis, and (5) relative use of memory aids of color, form, or spatial arrangement. Results indicated that all children performed better than chance and that their reconstructions were not mere chains of blocks, sequenced randomly one after another. (Author/RL)

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Reconstructive Memory: A Non-Traditional Approach To Assessing Young Children's Intelligence

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Running Head: Reconstructive Memory

ABSTRACT

Reconstructive Memory: A Non-traditional Approach

To Assessing Young Children's Intelligence

The evaluation of intelligence in young children has been particularly elusive. While memory components of intelligence, recognized as important aspects of intelligence, have been tapped through verbal memory, digit span, and other such subtests of standardized procedures, the verbal nature of the tasks has limited the reliability and validity of measurement in young subjects. The present paper discusses the implications for new instrument development by way of a methodological study which used a task allowing one to focus upon: (1) a non-verbal approach; (2) memory functions; (3) a variety of mnemonics that children use in information retrieval; and (4) a non-traditional procedure supported by psychological and developmental research.

Piaget's developmental theory has established that reconstructive memory processes are particularly useful indices in the diagnosis of young children's intellectual functioning. A Piagetian memory task (Static Imagery) was adapted to study the respective roles of color, form, and spatial cues in preschoolers' memory. A 7-element array of variously colored geometric forms was shown to each of sixtynine 4-and 5-year olds for 30 sec., after which an experimenter destroyed the arrangement, mixed the forms, and then asked the child to rebuild the pattern. The task allowed for an analysis of the child's (1) search and selection strategies; (2) approach to pattern reconstruction; (3) correctness of patterns, with the possibility for partial correctness; (4) classification skills based on the error pattern analysis, and (5) relative use of memory aids of color, form, or spatial arrangement.

The results indicated that all children performed better than chance and that their reconstructions were not mere chains of blocks, sequenced randomly one after another. There was a high degree of consistency between the child's search through the scrambled pile of blocks and use in placing each block in an orderly sequence during the reconstruction, indicating that spatial-positional information was guiding the search and use strategies more than color (e.g., looking for all the red ones first, the greens next, etc.) or form (e.g., getting the triangles first, the squares next, etc.). The error pattern analysis was suggestive of how children analyze multi-component arrays and break them down into smaller units, a skill necessary in many early childhood activities.

The results support young children's functioning at the level of figurative intelligence in their reconstructions. The discussion covers how this information can be taken into account as intellectual assessment tasks are designed for this age group.

Reconstructive Memory: A Non-Traditional Approach To Assessing Young Children's Intelligence

Introduction

The purpose of this paper is to consider the measurement of the elusive concept of intelligence from a so-called "non-traditional" framework. In order to do this, it is necessary to specify what constitutes the "traditional" approach. In the course of this discussion, the case will be made for a developmental approach to understanding growth changes in children's intelligence, and specific research studies will be cited which illustrate the practical utility in applying Constructivist principles discussed so frequently by Piaget (1970; 1972).

The Tradition of Measuring Intelligence

The testing movement grew out of British Empiricism. It is important to recall that bit of historical information for discussing the concept of intelligence, since British Empiricism was neither a psychological theory nor a developmental approach to the concept. Both of these features--non-psychological and non-developmental--will figure into a proposed alternative for looking at the concept of intelligence. It will be argued that it is time, in our scientific pursuits, to tackle mental processes from strong psychological theory and within a developmental framework.

The Empiricist tradition espoused a theory that "knowledge" is somehow a copy of reality and that perception alone could account for intelligence. Piaget, as a contemporary Structuralist, was not content with "perceptions" as the only raw material, and he insisted upon adding "action" to his definition

of intelligence. This addition is critical to understanding how intellectual life emerges and grows within the individual, since in this scheme knowledge is constructed through action. Action is further delineated into both physical and mental varieties.

The Constructivist position builds upon the historical, Empiricist background, rather than rejecting it altogether by including "perception" and "percepts" and relating them to intelligence. The copy theory of knowledge, however, does not follow.

In the Constructivist view, "understanding" and "knowledge" are not copies of reality. Intelligence proceeds from action, and such mental functioning transforms objects and it transforms reality. In fact, Piaget states that knowledge can be traced in the child as an active and assimilatory operation--knowledge is active and it is an incorporation. The important task, then, is to determine the relative roles of perceptions and actions in intellectual development (Piaget & Inhelder, 1969, p. 29). "Actions" will be a critical focus in this discussion for characterizing the growth of knowledge as a constructive process since action is essential to construction. Perception is likewise important to construction in two ways. First, we intend to show how a total reliance upon perceptual information has limited our understanding of the concept of intelligence, and second, that perceptions are important for illustrating that the relationship between percepts and concepts is the crux to "thinking".

The following may be said to summarize why the Empiricist approach to intelligence has not been good psychological science: (1) Empiricism is atheoretical, thus isolated in its account of human behavior, and (2)

Empiricism assumes that the concept--intelligence--is not different at different points in development. The issue for discussion involves mental growth and not changes which are due to environmental and experiential variations. For this purpose, then, it is necessary, first, to focus, on the relatedness of behaviors in humans and secondly, to consider how intellectual life changes in mental structure in the course of development, and how such a change in structure is not the same, nor dependent upon, changes in unique experience.

Piaget's early work with Binet's test taught him how to assess "what we know," but he tells us (Evans, 1973) that interactions he had with young children during his internship with Simon also taught him that the method and content would never help psychologists answer the question "how we know." The contemporary approach to measurement must be upon content-free definitions of intelligence. Looking for the answer "how do we know?" might provide a more enlightened approach to the assessment problem than continuing to ask "what do we know?" This approach, of course, is the heart of the scientific discipline Piaget constructed.

Piaget has also addressed another thorny problem of assessment. He always tried to separate ostensive performance from the internal structure of intelligence, which amounts to separating performance from competence--possibly the greatest feat of legerdemain one might imagine. The traditional, Empiricist approach has relied exclusively upon perceptually-based and content-loaded performance measures in assessing intelligence. No good theory would admit this procedure into its methodology, but then, the traditional approach has been atheoretical, so there has not been any

apparent conflict. Piaget's dissatisfaction with performance measures is that performance variables are the factors which are most influenced by the social environment and are subject to cultural bias. For example, Piaget rejected Jensen's heritability and intelligence argument (Jensen, 1969; 1973) because Jensen based his conclusions solely upon performance measures.

Thus, if we re-ask the earlier question of whether or not perception is sufficient to explain the development of intelligence, the answer is "no" for the following reasons: Perceptions are environmentally influenced and experientially bounded. The perception of an event is tied to that event and perceptions are specific in their content. However, let us consider where we go in our struggle if we add perceptions to "action" for a concept of intelligence.

If one accepts "concept formation" as a critical aspect of intelligence, then a case can be made for a direct connection between perception and concepts. The representation of an event in memory illustrates this connection. A specific example is the psychological concept, object permanence, used to describe the infant's continued awareness of an object or event after that object or event is no longer within the physical, perceptual field. Representations are removed from perceptual events by time or space (e.g., no longer present and may have occurred at an earlier time). Representation in memory is important to both traditional and non-traditional views of intelligence, since one has to remember and represent the event in memory if it is to be of any use in the future. Otherwise, all behavior would be devoted to invention and re-invention.

The first signs of the ability to make the connection between an event (perception) and the memory of it (concept) are seen in the infant's object permanence. This does not mean, however, that perceptions are indeed the basis of intelligence. Writers such as Michotte (1963) state that processes of perception prefigure concepts. Perceptions precede concepts and when the concepts finally are formed out of action by the individual, they are then "represented" and eventually comprise "representational" thinking. Thus, it may be that perceptions and the concept are closely linked, as in the case of object permanence during infancy, but in the majority of instances of intellectual functioning the perceptions are removed from the concepts by a considerable amount of time. Two clear examples of the percept-concept lag are children's use of size and shape constancies in their representational drawings and their conservation abilities. In both cases the perceptions are not directly tied to conceptual functioning. Piaget, in fact, pointed out that intelligence even influences perceptions later in the course of development. Such a position is quite different from one which proposes perceptual functioning and performance variables as the criteria of intellectual functioning.

Evaluating Intelligence

The preceding theoretical contrasts of the construct of intelligence have important implications for evaluation. The three components which have been emphasized in the discussion are: (1) actions, (2) perceptions, and (3) memory. These processes can be used in evaluating intelligence in young children as reflected in two kinds of memory representation: Recognitory Memory and Reconstructive Memory. Recognitory memory, the simpler of the two,

is based upon the individual's recognition of a previous event. Reconstructive memory, by contrast, requires active involvement by the individual in retrieving the components from memory and assembling those components in proper sequence in order to produce that event as faithfully as possible. What is also reflected in reconstruction is information about the child's (1) classification schemes, (2) classification criteria, and (3) consistencies or inconsistencies in applying self-selected classification criteria. If one is also willing to take the additional time to conduct an interview with the child around his/her performance and understanding of the task, additional data become available on reasoning strategies, verbal-reasoning skills, and the possibilities for separating the child's "performance" from "understanding." The remainder of this paper will be a discussion of a representative reconstruction task and the experimental data obtained with it. The discussion will focus on memory functions revealed through both accurate and inaccurate performances.

Static Reproductive Imagery

Piaget asks the "memory" question in the following way: "Is the child's internalization of a configuration different when he only perceives the configuration as opposed to actively constructing it?" (Piaget & Inhelder 1971, p. 230). For assessment purposes, this boils down to asking if there are performance differences between a child's recognition of a configuration and that same child's reconstruction of the configuration if given the elements. In the task used for the research reported here, the child was shown a model constructed from different, colored geometric forms (Figure 1). The child was allowed to observe the model for 30 seconds before being asked to copy it with a second set of geometric forms while the model was present. On the

second step of the task the child reconstructed the array from memory (no model present) and verbalized his actions for the reconstruction so that the tester who was behind a screen and who could not see the child's movements was able to build the same model that the child was constructing. A final, third step was for the child to choose what was remembered as the initial display of blocks from several choices that were mounted on a form board (see Figure 2). To summarize, the tasks assessed static imagery through: (1) copy; (2) reconstruction, as the child built the model from memory and communicated his/her actions to the tester; and (3) the recognitory skill, which required a match between a static mental image from memory and a physical representation of the original stimulus that was mounted on a display panel.

a) Recognitory Memory

Each of the five choices in Figure 2 was labeled according to the position of the error in each choice array. Thus, the error was labeled as an "initial," a "medial," or a "final" cluster error depending upon whether the anomaly lay in the beginning, middle, or end of each choice cluster. In addition to these three error choices and the correct choice, there was a fifth alternative which we called an "impossible" choice. This fifth option contained a color inversion so that yellow and green geometric forms replaced one another in the original set.

The task was used for evaluating recognition memory differences between two groups of nursery school children. It was found that the less experienced group showed randomly dispersed responding across all five choice options, while the more experienced nursery school group exhibited what were termed

"analogic" thinking (Cocking & Sigel, 1979). This is to say, the two groups of preschoolers exhibited differences in their memory errors, not in their memory accuracy. The errors of the more "advanced" children were analogs of the correct pattern, rather than a homolog.

The characteristic which distinguishes homologs from analogs is that homologs have structural unity requiring the entire pattern to be utilized when making a match with a new stimulus. Analogs, in contrast, are structural groupings which transcend class membership boundaries and reflect some sort of transformation. The clue to analogic thinking is generally the child's employment of commutative principles: "If A is like A' and B is like B', it is concluded that the entire structure is applicable to the new situation." In the recognitory choices presented on the form board, the initial and final clusters of the medial error correspond to the model that the tester built and of which the subjects formed static images. The discrepancy is embedded in the center of the array, and it appears that the match is made because initial and final clusters are alike and therefore it is concluded that the two forms match in all aspects. Alternatively, the medial cluster error may be termed a color analog, since commutative thinking might be based on color correspondences. Such a choice fails to coordinate the color similarities with the form discrepancy. The situation is a little different for the "impossible" or color inversion choice. While the color representations made the choice "impossible," the cluster array, in terms of form, did not differ from the correct array. That is, a color-blind person who viewed both arrays achromatically would not be able to distinguish between the two. For this reason, the color-inversion error results from applying the form homolog to the choice array.

What does error performance mean in relation to general memory functions? The predictive validity of this particular recognitory memory task was the focus of the research by Cocking and Sigel (1979). They found that in their study of homologic and analogic reasoning that the subjects who had previously employed error-related analogic thinking (44%), demonstrated a correct recognitory imagery-object match on a second trial 3 1/2 months later. In contrast subjects who utilized the homologic form match on the initial testing (23%) were still doing so 3 1/2 months later, and the remaining subjects were continuing to give responses which were randomly distributed among the other alternatives. In summary, those children who employed analogic thinking at Time 1 on the Recognitory Memory task were more likely to solve the problem correctly at Time 2 than those who employed any of the other strategies, including those who had given direct homologs of the correct choice ($p < .05$).

Recognitory memory, it appears, relates to the development of "thinking skills," and certain types of recognition errors have been shown to be more advanced than other types. Thus, errors are predictive of one component (memory) of intelligence. However, in recognitory memory someone else is providing the overall classification scheme for the subject, in that all of the information relative to the correct solution is out in front of the child and the task assesses the child's active search strategies for a match with the mental image retained in memory. Memory, however, falters as information is embedded in the array, thus accounting for the preponderance of errors to be related to medial clusters than to either of the end-point clusters (initial and final groups of three blocks). The child's active memory is engaged to devise mnemonics to keep the differences clear, and these memory aids are color, spatial, or form schemes.

b) Reconstructive Memory

In Reconstructive Memory, the child must devise the categories for reconstituting the array. The most efficient aids for storing the information in memory will be in terms of the features of the elements of the array--along the lines of color, form, or possibly even in terms of the spatial layout. The important thing is for the child to utilize a systematic scheme and not randomly apply all attributes idiosyncratically to each element--that is, a categorization scheme must be employed. Reconstructive Memory, therefore, is indicative of the accuracy of the child's memory performance, similar to traditional memory performance measures, but in addition, a reconstructive task tells us about the child's classification criteria (which have a developmental history); also it tells us about the application of the classification scheme; and finally, it tells us about the consistency of use of the selected criteria.

The procedure for the Reconstructive phase of the task, as mentioned earlier, was the presentation of a completed 7-element array of geometric forms of various shapes and colors--4 colors and 4 shapes without repeats of any color-form combination (Figure 1). After the child had looked at the display for 30 seconds and copied it with a second set of blocks, the experimenter mixed up the original blocks and then asked the child to rebuild the array. The copy-phase was employed to insure that all children had attended to the task and materials properly prior to evaluating their memory. The experimenter did two things during the child's rebuilding activities: she recorded the sequence in which the child chose the blocks from the randomly mixed pile, and she also recorded the block placement sequences in the final cluster for the purpose of comparing the reconstructed array with the correct sequence.

Thus, the procedure allowed us to consider children's search through collections of elements, which indicates whether or not they are looking for something specific to complete their block patterns. The procedure also produces a completed pattern from which one can infer the children's attempts to match the images they have of the original array. Most memory assessment, however, reflects only success or failure of the match between a criterion and the child's performance. It was hypothesized that the searching for, the reaching-for, and the placement of elements all reveal the relative importance of the cues of color, form, and spatial-position as memory strategies, all of which are thinking actions, as contrasted with thought products.

Subjects

We studied 138 observations taken from 69 middle-class preschool children on two test occasions separated by eight months. The children came from four different nursery school programs and were comparable in memory span abilities, as determined by that portion of a traditional IQ measure.

Separate analyses were computed for object-selection strategies and object-placement. With respect to overall accuracy of preschoolers' memory for a 7-unit block configuration, all children did better than chance. The correct placement of each element in its own position within the overall reconstructed pattern also exceeded chance ($t_{r_{pbi}} = 8.08$, $p < .001$).

The results showed a high degree of consistency between the child's selection of elements from the scattered blocks and the use of the elements to build the block pattern. The interesting finding was that children appeared to use spatial-positional information as the dominant organizing

memory cue for both block selection and in block use, rather than color or form cues. When the results were computed separately for younger and older subjects, using a median split, the effect was somewhat attenuated among the younger children, but the spatial-positional cue continued to hold as the dominant memory organizer across both groups.

The error patterns under both scoring systems--choice-strategies and placement-organization--confirmed that the children consistently made approximations to the correct positions, rather than producing chains of responses built from color or form similarities among the elements. They did not line-up all green elements, followed by red ones, etc., nor did they organize the elements so that the triangles were in sequence, followed by squares, and so forth.

The errors that are produced by a task of this sort also reflect where, in a series, the errors are likely to occur. The task also is enlightening about the process of error production and its relationship to accurate memory. Error analyses indicated that in considering elements in groups of three as a cluster, there was a significant error among the three elements to the left of center in the array. In constructing an error of this type, the child was likely to shift an element of the 3-unit cluster one position toward the right, thus embedding the erroneous element further into the center of the array. A second significant error type occurred for the three-element cluster just to the right of center in the array. In this error construction, the child shifted the erroneous element one position left, again illustrating that an error is likely to be embedded into the center of the total array. These patterns of displacement toward the center

of the configuration were significant across all positions and reflected a consistent approach, whether measured through coding for object-selection from the random pile or for coding the regenerated block structure.

Discussion

Let us reconsider Piaget's view that knowledge is not a copy of the object in terms of the two studies reported. Piaget stated that: "...[knowledge] is a perceptual construction made by exchange between the organism and the environment...", which is to say, an exchange between thought and the object of thinking (Bringuier, 1980). The Reconstructive Memory task illustrates the child's attempt to deal with reality through exchanges with materials upon which personal organizational criteria were placed. Clearly, the reconstructed knowledge did not mirror the criterion standard as copy theory would imply.

Reality must be known--at some level, at least. Since what becomes known is not a direct copy, the question becomes: How <u>is</u> reality known? Current developmental psychologies indicate that the child learns through mental and physical action, such as deduction and construction. If these are the processes of development and the task is to conduct an evaluation, shouldn't we evaluate the <u>developing processes</u> in the acquisition of knowledge? If the answer is affirmative, the corollary is that we will, necessarily, have to evaluate different processes at various points in the span of development. The area of developmental evaluation is where the traditional approach to intellectual assessment has failed miserably: the approach has not been developmental, and has simply accounted for <u>more</u> information as there was <u>more</u> experience to be reflected in age changes.

It should be pointed out that there have been many developmental studies which have looked for children's use of cues to help them remember. These studies have shown that reconstructive memory increases in accuracy as the children get older (Chi, 1977; Brown & Murphy, 1975; Corsini, 1972; Finkel & Smythe, 1973; Ward & Naus, 1973). In a search for the specific memory aids which children and adults use for their reconstructions, many studies have reported the developmental phenomenon that there is a shift from reliance upon color information among children to use of shape information (also called "object-identity") among more mature subjects. Bruner, et al (1966) have stated this behavior as a developmental principle: color gives way to form as a basis for classification as development proceeds. More recent studies have shown that preschool children also use object-identity information, given the proper tasks and proper measurement procedures (Ward & Naus, 1973). The finding is consistent with the present study which demonstrated that the process of reconstruction teases out spatial-positional cue utilization among young subjects if the experimenter's recording procedures accounted for process during reconstructive selection and placement strategies, rather than being limited to the information contained in completed products.

The developmental feature of assessment is important for another reason: it tells us that there should be some similar things happening across various domains of activities that children of a particular age engage in. The present assessment task can be put into this developmental framework. By contrast, pursuit-rotor performance or digit-span memory have not been demonstrated as having equally valid implications.

Research on children's drawings is one developmental area which yields corroborative evidence for the reconstruction behaviors assessed in the memory task. Drawing studies further indicate that spatial information is a critical cue in memory aid among preschool-aged children. Freeman (1975) points out that two things are learned through studying the evolution of children's figure representation. First, drawings tell us which cues children seem to pick up and utilize of their own accord. Secondly, the drawing process indicates how the child uses those cues (Freeman, 1977). The so-called "tadpoles" that 2 1/2-3 year-old children produce in their initial attempts to represent the human figure by drawing circles with legs and a navel are well-known phenomena. These tadpoles are an important piece of evidence that children spontaneously use spatial organization.

In the preceding discussion of children's error productions during the reconstructive memory task it was pointed out that errors became more prevalent as the elements being used were more removed spatially from the distinctiveness of the end points of the total array. Freeman pointed to a similar "anchoring" phenomenon when children are first learning to put pieces of the human anatomy together into a representation. The process of memorization for producing the serial order of body parts is to put the head at the top and the legs at the bottom. The constrained spatial serial order seems to help the child keep things straight. Freeman found that most tadpole drawers drew in the order of head first, followed by the legs, and only later the arms: the middle portion of accurate representation was found to come later, just as in the reconstructive memory task. In fact, some say that the tadpole figure is an epiphenemon of the memory strategy used: when you produce a head with legs and no arms, you

get the tadpole figure. Freeman (1977) says that "...the tadpole figure attests to the existence of a performance problem..." when the child tries to access a stored representation. That is, the tadpole figure is a performance error due to inefficient accessing of information from memory. The child knows what a person looks like, and for that matter, can look around for a model, but the child doesn't retrieve from memory efficiently, even after copying someone else's drawing which contains all the parts, including arms. Clearly, the child knows what a person looks like, but when he accesses that information as a stored representation, the anchoring process of end points of head/legs is the memory aid, and what we see is the production of a tadpole. Children's spontaneous drawings also show that not only is the head more commonly drawn than the trunk, but that the legs are also more common than the arms. What's left out?...the middle parts, all of which points to the fact that spatial information is a useful cue in young children's reconstructions from memory.

Summary

In conclusion, we have tried to illustrate that developmental features of the concept of intelligence need to be included in assessment procedures. The processes that are the targets of assessment should have wide generality and not be limited to any one specific domain. The procedure also should be able to separate performance and competence aspects of the concept, at least in theory, if not in practice.

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Static Reproductive Imagery

G = green
R = red
Y = yellow
B = blue

Figure
1

Static Reproductive Imagery: Choices

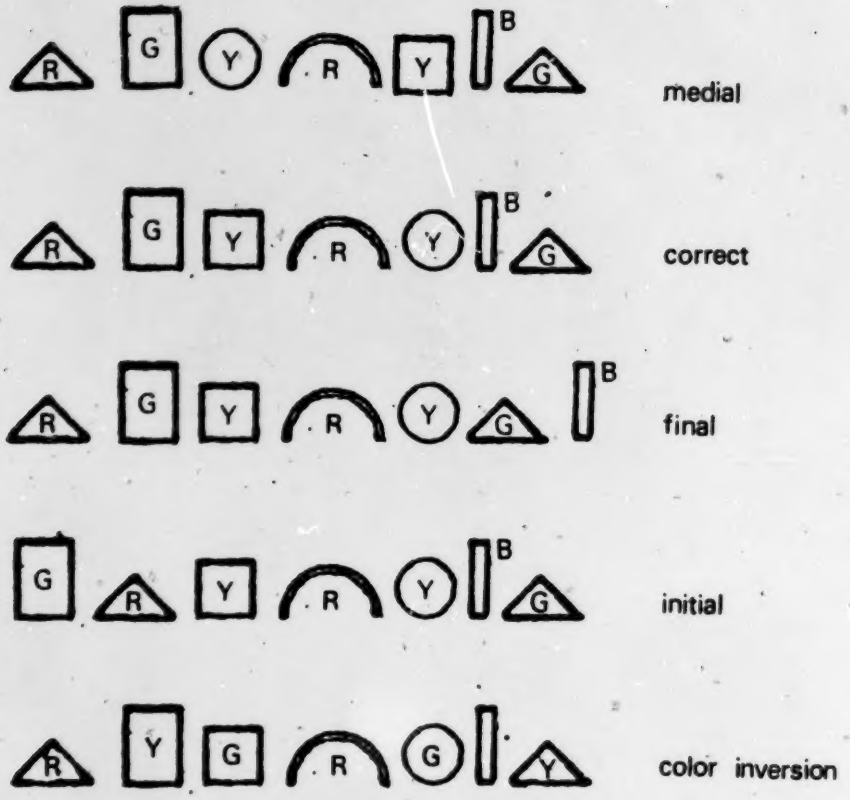

FIGURE 2